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Shear Banding in Wormlike Micellar Solutions

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wormlike micellar solution の shear banded 状態における時空間構造について、Ginzburg-Landau スキームにもとづいたモデルを数値的に解いて議論する。(1) shear stress が一定である条件下での shear rate の空間平均の時間的挙動、(2) shear rate が一定である条件下での shear stress の空間平均の時間的挙動、(3) それらの違いと空間的構造との関係、について報告する。stress-diffusion coupling が重要な役割を果たすことを強調したい。

1 Introduction

Complex materials, such as wormlike micellar solutions, often exhibit remarkable rheological behavior in shear flow. Shear banding is one of such phenomena whose spatio-temporal structures have been attracted much attention in recent years.

2 Model

We numerically investigate the spatio-temporal behavior in wormlike micellar solutions under shear using a time-dependent Ginzburg-Landau model[1]. In Fig.1, we display a stress-strain curve in homogeneous states. The region $\partial\sigma_{xy}/\partial\dot{\gamma} < 0$ is unstable and shear bands appear.

3 Results

In Fig.2, we show the erratic temporal fluctuations of $\langle\dot{\gamma}\rangle(t)$ and some snapshots of $\Phi(\mathbf{r}, t)$ (composition) and $\dot{\gamma}(\mathbf{r}, t)$ (shear rate) at fixed shear stress. The large-amplitude fluctuations and highly unstable interfaces between bands are more pronounced closer to the coexistence curve in one phase region. In Fig.3, we present the temporal fluctuations of $\langle\sigma_{xy}\rangle(t)$ at fixed shear rate. Appearance of irregular “beats” is in accord with recent experiments[2,3].

References

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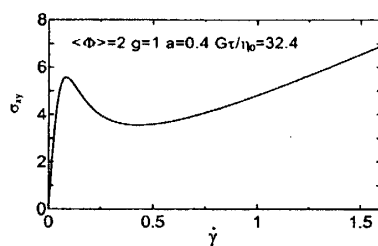


Figure 1: Stress-strain relation for wormlike micellar solutions in homogeneous states.

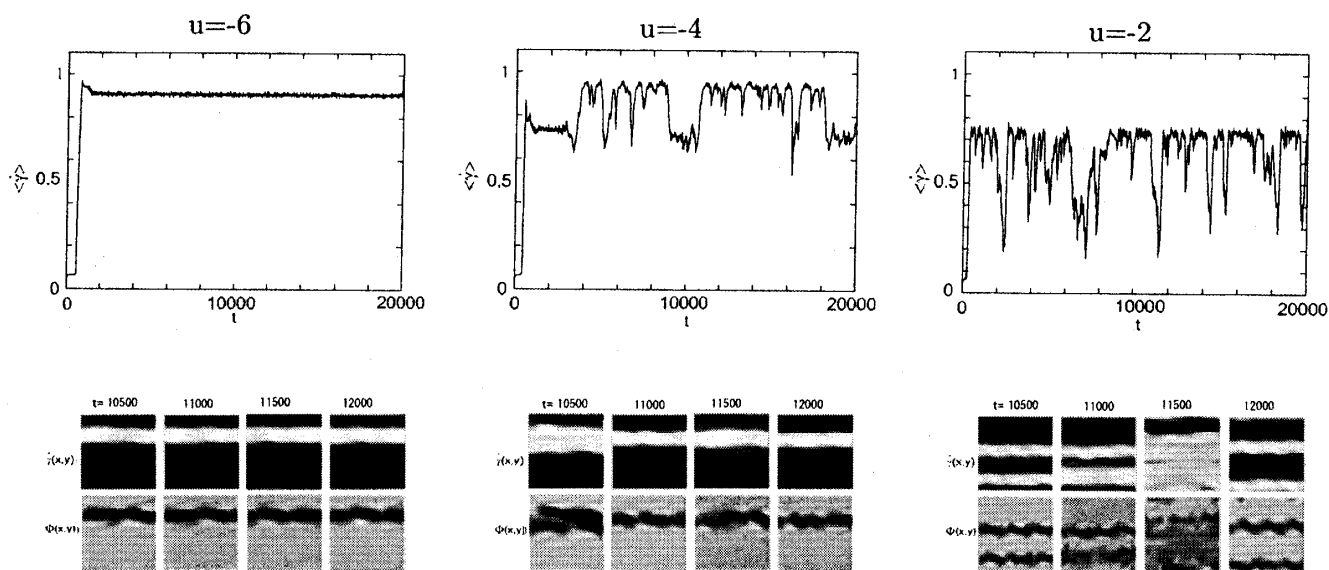


Figure 2: Time evolution of the average shear rate $\langle \dot{\gamma} \rangle(t)$ and snapshots of $\dot{\gamma}(\mathbf{r}, t)$ and $\Phi(\mathbf{r}, t)$ for $\langle \sigma_{xy} \rangle = 5.4$. From left to right, $u = -6, -4, -2$, respectively. $u = N^{1/2}(2\chi - 1)$, χ the interaction parameter.

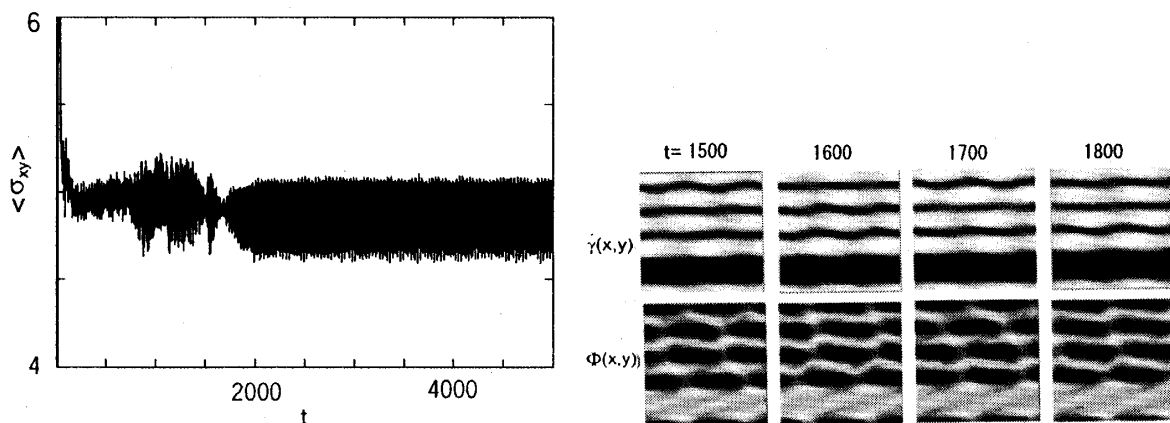


Figure 3: Time evolution of the average shear stress $\langle \sigma_{xy} \rangle(t)$ and snapshots of $\dot{\gamma}(\mathbf{r}, t)$ and $\Phi(\mathbf{r}, t)$ for $\langle \dot{\gamma} \rangle = 0.4$. $u = -6$.